Exploring Asymmetric Competitive Gaming For Mixed-Visual-Ability Pairs

Pedro Trindade[1[0009−0000−4648−5611]], David Gonçalves[1[0000−0001−6223−4011]], Pedro Pais[1[0000−0002−9364−6403]], João Guerreiro[1[0000−0002−0952−8368]], Tiago Guerreiro[1[0000−0002−0333−5792]], and André Rodrigues[1[0000−0002−0810−4619]]

LASIGE, Faculdade de Ciências, Universidade de Lisboa, Lisboa, Portugal
`pgtrindade, dmgoncalves, pgpais, jpguerreiro, tjguerreiro, afrodrigues @ciencias.ulisboa.pt`

Abstract. Competitive games assume stereotypical players with equal abilities face mostly symmetric gameplay. For mixed-ability groups, equal challenges limit the design space and can be unappealing. Conversely, introducing asymmetric play raises concerns about fairness and balance. This work first explores competitive mixed-visual-ability games, focusing on understanding players' perspectives of competition, fairness, transparency, and asymmetric play. Through a mixed-methods study involving six sighted and four blind participants, we examined player experiences across four combinations of a/symmetric play. Our results reveal how disability disclosure can affect the experience, how design choices of asymmetry affect the perceived fairness, that asymmetric competition can be engaging, and the nuances between the perspectives of sighted and blind players. We highlight that while asymmetric design presents an opportunity for fostering competitive mixed-ability environments, it necessitates thoughtful design where skill and disability are not conflated, ensuring that different in-game challenges are either equally demanding or that the overall game experience reflects a balance of what is demanded of players.

Keywords: Competitive gaming · Accessibility · Mixed-ability · Visual impairments · Asymmetry.

1 Introduction

Digital games play a significant role in fostering socialization and connecting individuals across different contexts, backgrounds, and age groups [43, 47, 35, 18]. Competitive gaming was shown before to have various social benefits, acting as a platform for people to come together, bond, and build communities [28, 9].

However, most games are designed without anticipating the needs of individuals with disabilities, rendering them inaccessible to a big portion of the population [25, 5, 49, 23, 7]. Prior work [17] has shown how blind players (and content creators) manage to play a subset of mainstream games by using existing game mechanics to overcome accessibility barriers (e.g., utilizing weapons to feel their surroundings). These players are the exception, and despite their efforts, they often have to use external resources and face challenges not intended by design (e.g., persistent trial-and-error), which in multiplayer competitive games creates an extreme imbalance between players (e.g., in Call of Duty [31] not being able to determine and adjust crosshair height). For blind players, playing with others typically means mainly engaging with games specifically designed for them (i.e. audio games) in a segregated community based on visual ability with limited to non-existent play with sighted peers [19].

Asymmetric game design provides players with distinct gameplay experiences, differing in-game abilities, challenges, and information [14, 29], among others. Past work [20] has shown how to leverage asymmetry to create inclusive mixed-visual-ability cooperative games, ensuring balanced player contributions with players equally engaged in a single cooperative experience. We believe there is an opportunity to leverage the same design principles to create competitive games. However, the issue shifts from perceived equal contribution and autonomy to the fairness of asymmetric competition. In this work, we explore how different a/symmetry types affect the perceived fairness and experience of sighted and blind players in competitive games.

To achieve this, we developed a game prototype that had players compete to be the fastest in creating four magical items. Players had to complete a/symmetric challenges to create these items. We conducted a mixed-methods study with six sighted and four blind participants. In each session, participants played the game and were told they were competing against another player online. This was followed by: 1) the Mini PXI [1] questionnaire to measure the overall player experience, 2) telling the players they were competing with someone with different visual ability than their own (i.e. sighted or blind) and explaining how they were playing and competing, 3) a fairness questionnaire regarding the a/symmetries experienced, and 4) a semi-structured interview, focused on understanding the impact of the design choices on player experience, perceptions of fairness, mixed-ability competition and disability disclosure. Our research questions were:

- How do players perceive competition and fairness in mixed-visual-ability competitive gaming?
- What are players' perceptions about different symmetric and asymmetric approaches to mixed-ability gaming?

Our findings demonstrate that asymmetry in competitive mixed-visual-ability contexts has the potential to create engaging experiences where differences in abilities are not limiting. Notably, asymmetric game design tended to be perceived as fair when tailored to each player's abilities. On the other hand, symmetric play restricts sighted users to audio-only gameplay (while fair, hurts the experience), representing the status quo of no cross-play between communities. We highlight how disability disclosure and expectations of play affected sighted and blind players differently. Lastly, we discuss how skill and disability should not be conflated but represent a new design challenge for the field.

2 Related Work

In this section, we cover the state-of-art of visual accessibility in games and current alternatives to vision-centric games (i.e. audio games), past research centered on asymmetric game design, and the role of fairness in competitive gaming.

2.1 Playing blind

For blind players, visuals in digital games need to be replaced with audio feedback through the use of text-to-speech, audio cues (e.g., footsteps), descriptions and/or sonification (e.g., unique sounds for different objects) [13, 20] as well as haptic feedback [10, 3, 21]. Efforts to make blind-accessible games often involve adapting existing games that did not consider players with disabilities during the design process, like AudioQuake [5] (Quake) and Blind Hero [48] (Guitar Hero). However, *a posteriori* attempts to adapt games whose core gameplay is based on visual engagement may harm the player's experience [49, 19]. In contrast, some recent games [12, 44] are launched with accessibility options that make them fully playable by blind players. While these are remarkable advances, they are the exception, as most titles still have no consideration for blind players' needs and depend on vision [40, 17].

Prior work has explored design solutions to augment or propose alternative techniques for environmental awareness [36, 37] and navigation [39]. Notably, the RAD [42] is an auditory interface proposed by research to make racing games accessible to blind players. The approach created an asymmetric interface for blind players (e.g., audio cues for an upcoming curve), which made it possible to compete without significantly different lap times or driving paths against sighted players. Since then, the technique has been announced to be leveraged in the recently released commercial game Forza Motorsport[45][1]. However, even in this successful instance, it is still a challenge to have blind players competing with other cars on the track, given the difficulty to accurately convey other vehicles' position—disabling vehicle collision is available as an accessibility feature in Forza Motorsport, but it cannot be enabled in multiplayer matches. While asymmetry of the interface can effectively align audio ability with sight, it is most likely impossible to match the throughput of visual perception with audio in complex games. This means players are either at a disadvantage against their sighted peers or limited to more simple/controlled environments for competition.

Despite advances achieved by the industry and research, most games are still inaccessible to many people (especially blind) [40, 19]. Also, there is no understanding of how one can design inclusive multiplayer games where abilities are not limiting to the experience. In the few mainstream games accessible to blind players, challenges are usually made accessible through options that allow players to skip, diminish, or totally alter the challenges posed [17]. It is unclear how

[1] John Walker (12/09/23). Forza Motorsport's Blind Drive Assist Is A Breakthrough For Gaming Accessibility. Kotaku URL: `https://kotaku.com/forza-motorsport-xbox-blind-accessibility-options-race-1850829331` (visited on 20/02/24)

multiplayer games could incorporate these options and changes while maintaining the shared experience engaging and balanced. This is a notable challenge in competitive games, where differences in the gameplay between players (e.g., aim assistance for some players) can lead to a sentiment of unfair play [11].

Audio Games Audio games are games with audio-based gameplay. They provide information to the player through text-to-speech and unique sounds for each game element, allowing players to differentiate between various sound patterns. At AudioGames.net[2], a repository of sound-based games, a great variety of audio games genres and themes can be found, such as Manamon [46] (a Pokémon-like adventure game), and Crazy Party[41] (arcade-style minigames and card battler), among many others, of which some are competitive audio-only games. Audio games struggle to reach popularity among the mainstream gaming community because they are difficult and unappealing for sighted people due to the lack of visual information [19, 4]. Furthermore, research examining the involvement of sighted players in audio games remains scarce [2, 32].

Universally Accessible Games Grammenos et. al. [24] introduced the concept of Parallel Game Universes as a means to create universally accessible games. This approach involves tailoring the game experience to individual player abilities, allowing for more inclusive gameplay. While successful in simpler games (e.g. chess [22], tic-tac-toe [38] and space invaders [24]), scaling this methodology to more complex games may present challenges due to the potential need for significant simplification and the potential limitations in certain gaming contexts. Moreover, in a mixed-ability competitive gaming context, ensuring fairness presents a challenge due to the impracticability of uniformly applying rules [25] as not all challenges can be accessible without significant changes.

2.2 Asymmetry for Mixed-Ability Play

Asymmetric design creates different gameplay mechanics for different players [14, 29]. Prior work has proposed a set possible *mechanical manipulations* that designers can leverage to create asymmetric player experiences [29], such as asymmetry of ability, challenge, interface, information, investment, and goal/responsibility. In the context of mixed-ability, asymmetries can be designed toward specific individual abilities. In prior work, asymmetry has been leveraged for mixed-ability cooperative games for blind and sighted people [19] and for wheelchair users and people without motor impairments [15]. The previous approaches have focused on cooperative play, designing for pairs of players with interdependent roles, and tailoring one role specifically for the target ability.

In Kinaptic [21], researchers design a competitive mixed-ability tag-like game for blind and sighted players. The study focused on providing different modalities

[2] AudioGames URL: `https://www.audiogames.net/` (visited on 20/02/24)

for players (i.e. TV for visual feedback while blind players relied on a haptic device, wind, and 3D sound). The study evaluated how these alternative interfaces influenced players' ability to perceive and interact with the game environment, yielding mixed results. Despite the few works on mixed-ability gaming, our understanding of how players perceive and experience competitive mixed-ability games remains limited. Specifically, the intricate issues of fairness and transparency.

In asymmetric competitive games, round-based gameplay where teams/players switch roles (e.g. Predator: Hunting Grounds [30]), is often used to address any potential imbalances in the likelihood of one role having a higher chance of success (i.e. the game being imbalanced). This also opens up the design space as seen in previous works in VR asymmetric play, where roles are expected to be reversed, and thus imbalance between the two players is a core part of the game design. Gugenheimer et al. [26, 27] found that variations in "power level", resulting from asymmetries in information, ability, and interface, could enhance player enjoyment. However, embracing this imbalance is only possible when roles are reversible. In mixed-ability scenarios, when roles are designed based on ability, some roles cannot be played by everyone, and thus purposeful imbalance is not desirable. However, as shown by work on cooperative games, asymmetric games can create engaging experiences for groups with mixed-abilities. The question is, how can we create competitive experiences that are perceived as fair by the players?

3 Competitive Mixed-Ability Testbed Game

We developed Cryptic Kitchen[3], a testbed game to explore players' perceptions of mixed-ability competitive gaming and different asymmetric design approaches. We aimed to provide a cohesive gaming experience where players were exposed to various game mechanics while their opponents could have the same, equivalent, or completely different ones. The goal was for players to compete and, after the gameplay session, be exposed to the other player's mechanics and informed of their different visual abilities to reflect on the variety of competition types created through asymmetric design. We carefully designed the game, aiming for a balance despite the asymmetries, as we sought to create an experience where players felt they were competing with their peers on equal terms.

While asymmetry is often used to create a purposefully different experience for both players, in this work, we aim for players to have the same in-game **abilities**, to be competing over the same **goal**, to have access to the same **information** and to require the same **time** investment [29]. We limited our exploration of asymmetry to **challenge** and **interface** as identified by Harris et al. [29], as we believed to be the most promising given the prior work on mixed-ability competition [21] and cooperation [19, 15].

Below, we provide an overview of the gameplay, navigation, orders, and inventory system, followed by describing the four challenge combinations used

[3] Cryptic Kitchen. URL: `https://techpeople.itch.io/cryptic-kitchen`

(i.e. Symmetric Audio-Only, Symmetric, Asymmetric Interface, and Asymmetric Challenge). We also provide a video demonstrating the challenges and navigation[4].

3.1 Design and Implementation

Testbed Gameplay Inspired by the mechanics of the Overcooked [16] series, Cryptic Kitchen[3] is a competition between two magical chefs. Set within a 2D top-down environment, players **navigate**, gather ingredients, use **stations** to imbue ingredients, which open a challenge (i.e. moments of a/symmetric play described below), and fulfill **orders**. Blind players use the keyboard and sighted also use the mouse.

Navigation The map (Figure 1) was designed to have an equal traveling distance and time for sighted and blind players. Sighted players freely navigate the environment, while blind players navigate through a waypoint system (e.g., when pressing left the character automatically moves to the next waypoint on the left), both using the keyboard WASD/arrow keys. The navigation system is, therefore, only asymmetric in interface.

Fig. 1. Central Room (E); Delivery Room (F); Potency Room (D); Effect Room (C); Element Room (B); Inscription Room (A); Ingredients chests (G); Cooking Stations (H); Player Character (I); Scoreboard (J); First Order (K); Second Order (L); Item In-Hand (M).

Inventory and Orders We use Text-to-Speech (TTS) to grant access to inventory/orders to blind players, meaning they hear one item description at a time. Sighted players, on the other hand, rely on visual representations of their inventory and orders (Figure 1), but can also view only one item at a time from the three available (order one, order two, and inventory), which are hidden by default. The inventory/order system is, therefore, only asymmetric in interface.

[4] Demonstrative video of the game prototype. URL: `https://osf.io/zr43e`

3.2 A/Symmetric Cooking Challenges

Cooking Station Interacting with a cooking station (e.g. Figure 1-H) will open a challenge (Figure 2). Upon completion, the item remains locked in the station for 30 seconds, incentivizing players to multi-task and start the next order in another station. Below, we detail the four challenges implemented, two symmetric and two asymmetric:

Symmetric Audio-Only (SAO) - Pairing Cards. Baseline condition equivalent to an audio game with no visuals. Players face the **same auditory challenge**, with the **same interface**. This game models a traditional memory card game. The player has to find 4 card pairs in a pool of 9 cards by selecting two cards with the same sound. Players used the numpad or number keys to select card positions.

Symmetric (S) - Isolate Pattern. Players face the **same challenge** and have the **same interface** (Figure 2-C), but only sighted players can leverage the visual feedback. Players are tasked with adjusting three knobs, using the directional keys to isolate a sound (e.g., fire sound) and/or a visual pattern. The sound associated with each knob is only being played while the player is adjusting it, i.e. there are only two sounds simultaneously playing: the one required to be isolated and the knob sound.

Asymmetric Interface (AI) - Moving Goal. Players face **the same challenge** with **distinct interfaces** (i.e. visual-only or audio-only feedback). The player has to stay inside a moving score zone for a given amount of time using the directional keys (Figure 2-D). Blind players have to follow the sound, using the spatial audio to determine the target position, and when on target, they hear a continuous scoring sound. Sighted players only have visual feedback (i.e. a moving target).

Asymmetry of Challenge (AC) Players have **distinct challenges** and, consequently, **distinct interfaces**. Blind players have the Find Sound challenge (Figure 2-B), and sighted ones have the Find Silhouette (Figure 2-A). **Find Sound.** The player is located in a random cell in a 5 by 5 grid and has to reach the goal which plays a unique sound. After every movement, a positive or negative cue indicates whether if they are closer or further from the goal. Moving against the grid limit plays a "bump" feedback sound. **Find Silhouettes.** The player is shown several different items floating across the screen and knows which ones they have to select. After a short delay, only generic silhouettes/shadows are displayed and the player has to select all the correct ones. Incorrect guesses temporarily block interactions. Pressing the spacebar shows the player the different items' colors/shapes for a short time but blocks selection.

Development & Playtesting The game was developed in Unity[5] along with Photon Engine[6]. During the development process, we conducted playtesting with a group of selected individuals (sighted and one blind player), whose feedback was iterated to ensure usability.

[5] Unity URL: `https://unity.com/` (visited on 20/02/24)
[6] Photon Engine URL: `https://www.photonengine.com/` (visited on 20/02/24)

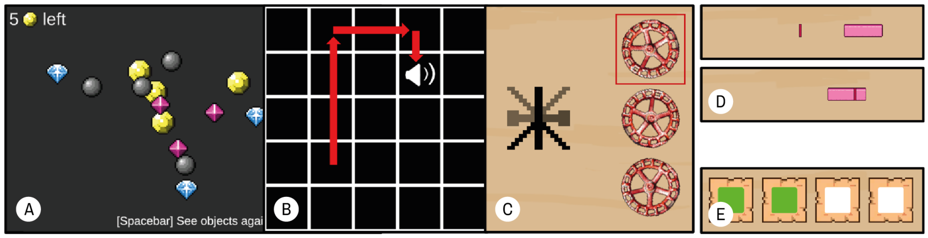

Fig. 2. Minigames developed: (A) Asymmetry of Challenge (Sighted) – Find Silhouettes: moving target and decoy items to track, before only the silhouettes are visible; (B) Asymmetry of Challenge (Blind) – Find Sound: grid layout with an auditory path leading to the target sound. (C) Symmetric – Isolate Pattern: three knobs (right) can adjust sound volume and the pattern image (left); (D) Asymmetric Interface – Moving Goal: the player marker (vertical bar) and the moving goal (horizontal bar); (E) Symmetric Audio-Only – Pairing Cards, the game's scoreboard indicating the number of card pairs found.

4 User Study

We conducted an in-person user study with sighted and blind participants. Our goal was to explore players' perspectives about different types of mixed-ability competition to understand how it can be designed to create an engaging and fair gaming experience. The study was approved by our school's Ethics Committee.

4.1 Participants

We recruited 10 participants, six sighted and four blind. Sighted participants were aged 22-29 (M_S=24.83; SD_S=2.97). Blind participants were aged 30-43 (M_B=37.5; SD_B=5.32). Participants filled in an online form with demographic information (i.e. age, gaming frequency, and competitiveness).

Our participant pool had sighted players identified as more frequent gamers than blind players. All blind participants engaged in gaming monthly, while the frequency of sighted participants was generally higher. Among sighted participants, only one individual, S1, identified as a casual player, while the remaining participants identified as either between casual and hardcore or hardcore players. Among the blind participants, B4 was between casual and hardcore, while the others identified as casual players. Participants S2, B3, and B4 identified themselves as very competitive individuals.

4.2 Procedure

Participants received a standalone game version before the in-person session containing only the four challenges corresponding to their visual abilities. Participants were encouraged to familiarize themselves with the different in-game challenges. During the in-person study play session, participants were asked to complete a questionnaire[7] about their play of each challenge and their perception of their difficulty level.

Participants were then guided through a step-by-step tutorial showcasing the controls and mechanics of the full game (i.e. navigation, orders, inventory, stations, and delivery). Participants were required to complete two orders during the tutorial. Next, participants were informed they would engage in an online competition with another participant, racing to be the first to complete four orders. Importantly, participants were not yet aware of their opponent's visual abilities, nor that both players would be engaging in different versions of the game based on their abilities.

Competition. In all sessions, the opposing player was a researcher playing remotely using the opposite game version (e.g., sighted player gameplay when their opponent was blind) following a script replicating playtesting sessions. This approach upheld a competitive experience while ensuring that each participant could progress through the step-by-step tutorial at their own pace, without any delays or interruptions, facilitating recruitment, scheduling and study execution, and streamlining the logistics of the study. During the gameplay session, the researcher offered minimal assistance to minimize their influence on the game's outcomes. Additionally, the game only ended once at least two deliveries were completed by the participant, even if they already lost (i.e. 10 minutes and 32 seconds for blind participants and 8 minutes and 26 seconds for sighted participants).

Upon completion of the game, participants were prompted to fill the Mini PXI [1] questionnaire to ensure that participants perceived the game as engaging, as a lack of engagement could potentially skew perceptions and impact the overall player experience. At this stage, participants were informed that the game was designed for mixed-visual-ability play. They were also made aware that their opponent possessed different visual abilities (i.e. sighted, or blind). We conducted semi-structured interviews[8] focusing on their views on mixed-ability competition, the perceived fairness of the main game mechanics, gameplay, and each a/symmetric challenge. During the interviews, participants were informed about the challenges (i.e., moments of asymmetric play) faced by their opponents. For blind players, the gameplay was described, while sighted players experienced their opponents' challenges firsthand. Participants' perceptions of fairness were additionally captured on a scale of 1, "In Disadvantage", to 5, "In Advantage", in comparison to their opponent.

4.3 Data Analysis

After transcribing interview audio recordings, we performed a mixed deductive-inductive codebook thematic analysis [8] over all open-ended questions of the interview. We familiarized ourselves with the data by iterative reading, then the first author developed codes based on research questions, data familiarity,

[7] Minigames Questionnaire. URL: `https://osf.io/zmch7`
[8] Semi-structured Interview Script. URL: `https://osf.io/ed5kn`

and study observation. The team discussed interpretations and developed a preliminary codebook. The first author coded all interviews, adding new codes as needed. Themes were identified and named through iterative sessions, supported by quantitative engagement and fairness data.

4.4 Findings

The descriptive data presented below serves only to contextualize the play session, as our goal is to explore the perspective around the fairness of different a/symmetric design choices; it is not intended to be generalizable given the small sample and the disparity within it (e.g., game expertise).

The Mini PXI results show players overall classify their enjoyment as high (M_O=2.7, SD_O=0.6). Sighted players were, on average, faster in all challenges, with the largest discrepancy in the Symmetric (M_S= 8.2s vs M_B=18.6s), and the smallest in the Asymmetry of Challenge (M_S= 12.5s vs M_B=15.2s), Figure 2-A and 2-B. It is worth highlighting that even in the Symmetric Audio-Only minigame, Figure 2-E, sighted participants were on average 9 seconds faster (M_S=22.3s vs M_B= 31,8s), which is likely to result from the demographic difference in the expertise and frequency of play.

We now present the themes identified during our qualitative analysis, highlighting participants' reflections on fairness, competition, and their experiences with the a/symmetric design choices.

Designing a Mixed-Visual-Ability Game Blind players were required to rely heavily on their memory to keep track of crucial information, such as their current location, objectives, and challenges. This information is quickly perceived visually (e.g. entering the game with knobs and recalling the interaction method, Figure 2-C), while audio requires memorization. The variety added by having multiple challenge types forced players to switch between gameplay interactions exacerbating the issue. In principle, while all challenges were designed to require the same proficiency and potentiate equal performance, it is only true when we consider them in isolation.

Similarly, while we made efforts to ensure fair navigation by meticulously ensuring that the same information is presented, at the same time, and equal path time travel, the persistent nature of visual feedback contrasts with the one-time audio cue announcements (e.g., room name when entering).

While designing for a balanced experience equal information and feedback can make the experience accessible and fair from the strict concept of equal information, it inadvertently creates an imbalance in the demands towards players.

Fairness Perspectives Regarding the game as a whole, some sighted participants perceived they had an advantage throughout the game, while others considered the game a fair experience. During the game, the scoreboard was hidden by default with only two sighted (S4 and S6) and one blind (B1) player using it. As such, some sighted participants believed they were falling behind.

Table 1. Minigames Fairness Questionnaire. Participants rated fairness on a scale of 1, "In Disadvantage", to 5, "In Advantage".

Participants	AC (SD)	AI (SD)	S (SD)	SAO (SD)
Sighted AVG	2,8 (1,1)	4,5 (0,5)	4,0 (0,8)	3,0 (0,0)
Blind AVG	2,8 (0,4)	3,0 (0,0)	2,5 (0,5)	3,5 (0,9)
Overall AVG	2,8 (0,9)	3,9 (0,8)	3,4 (1,0)	3,2 (0,6)

"*Overall, I think it was quite balanced. We were almost neck and neck. Actually, I thought the other person was ahead.*" (S1)

On the other hand, blind participants generally perceived the game as a balanced experience and attributed any differences in performance to a lack of training and familiarity with the game.

"*I think it's very similar to the objective of both me and the person on the other side... adjusted to the needs of each individual.*" (B3)

However, participants had different perspectives when discussing the challenges (Table 1).

Symmetric Audio-Only Challenge is Fair but Visually Unappealing. The symmetric audio-only (i.e. Paring Cards), Figure 2-E, with audio-only play was considered the fairest by all, except B4, who believed he had an advantage due to his familiarity with audio-based games. Importantly, not all sighted participants enjoyed the challenge due to a lack of visuals reiterating findings from past work [19].

Visual feedback perceived as an advantage by sighted players in symmetric challenges. When the challenge was the same (i.e. Moving Goal, and Isolate Pattern), Figure 2-D and 2-C, it did not matter how the audio feedback was designed, sighted players believed to always have an advantage due to visual feedback being faster to interpret than audio.

"*Perhaps a blind person can play that game flawlessly. I couldn't, nor could I see how my progress would improve.*" (S5) when discussing the blind players' Isolate Pattern minigame, Figure 2-C

"*If he could discern the fire and wind like I visually see, [...] it would be exactly the same (in terms of fairness).*" (S5)

Conversely, for blind players, asymmetric interface (i.e. Moving Goal), Figure 2-D, was unanimously considered fair. We do not fully understand whether this discrepancy is an effect of sighted players being able to test the audio-base gameplay, or if it stems from sighted players' pre-assumptions of the performance of blind players (or themselves) with audio-only versus visual gameplay.

Information Availability. When discussing the Symmetric challenge (i.e. Isolate Pattern), Figure 2-C, opinions were split among blind players.

"*I felt more disadvantaged. The game utilizes vision, whereas I rely solely on hearing.*" (B2)

Despite sighted players having access to more feedback and consequently more available information, two blind players commented that sighted individuals often disregard the auditory stimulus. Consequently, they considered that sighted players having both visual and audio feedback did not necessarily confer an advantage.

This points to design opportunities where the audio becomes an essential and sufficient part of the challenge but complemented by redundant and/or non-essential visuals (e.g., Isolate the Pattern could have the knobs visually turning to different sides, but without the transparency to isolate a pattern).

Asymmetry of Challenge was perceived as fair. On average, the asymmetry of challenge tended to be considered the fairest (M_O=2.8, SD_O=0.9) (Table 1). However, these results come from a disparity in the views of sighted participants, with three believing they had the disadvantage, two equal, and one the advantage. In contrast, only one blind participant believed he was at a disadvantage. Participants shared an overall perception that different challenges, as long as they are designed based on individual abilities, are fair, even if different. Depending on design choices, they may favor one player or the other, but by principle, it is the choice that should be made.

"*It's about* ***equivalence****, arriving through audio or through images. But ultimately, the goal is the same. Instead of silhouettes, we have sounds.*" (B1)

This further highlights the promise of an asymmetric-based design that caters to individual abilities rather than accommodating them via changes in interface and feedback.

Competitiveness & Transparency in Mixed-Ability Play Some sighted participants disclosed they would have been less competitive and put less effort into winning if they knew their opponent's visual disability. This attitude contrasts with the perspective of blind participants, who saw themselves as equally capable competitors in mixed-ability gaming. This highlights the tension regarding the disclosure of disability in multiplayer games and how it can impact the experience of all involved players. We believe this type of mixed-ability game represents an opportunity to educate people to overcome their misconceptions about the abilities of blind players.

5 Discussion

Asymmetric competitive mixed-ability gaming can and did create an engaging experience for pairs. Players had a positive experience and expressed their appreciation for the opportunity to engage and interact with individuals with different visual abilities (RQ1). In line with prior work, our findings also reiterate: 1) the lack of games that can be enjoyed by both people with and without visual impairments [49, 40, 34]; 2) how audio games are not appealing to sighted play [19, 4]; and 3) how simplifying games for equivalence and accessibility can reduce engagement [19, 49].

5.1 How do players perceive fairness in asymmetric mixed-ability competitive gaming (RQ1)

The discrepancy in perceptions of fairness raises questions about the role of knowledge and biases in shaping players' experiences. While in competitive gaming one would expect fairness to come from symmetric play, in mixed-ability gaming that is only consensual and achieved by creating the *de facto* audio games that sighted players will not engage with; the best alternative appears to be relying on the **asymmetry of challenge**. While it may be tempting to rely on **asymmetry of interface**, it will more likely inadvertently produce imbalances and will restrict the complexity of games capable of delivering equivalent challenges. Such constraints could result in simpler experiences that may not be equally engaging for all participants.

In particular, there are open challenges in designing asymmetric competitive games where players have game mechanics that directly interact with the other players' gameplay. Moreover, we only explored perceptions of pairs of players, but how can we scale mixed-ability gaming to mixed-ability groups composed of a varied number of players with and without disabilities? How can we design experiences that are balanced and perceived as fair by all?

Lastly, we believe the bias displayed by sighted players presents an opportunity to design thought-provoking games that purposely create imbalanced experiences (e.g., using asymmetric gaming or dynamic difficulty adjustment [6]). These designs can leverage sighted players' perceptions of their advantage to educate them about the fairness of play with people with disabilities.

5.2 Asymmetry for competitive mixed-ability play (RQ2)

Asymmetry in competitive mixed-ability games brings forth unique and dynamic gameplay experiences. However, ensuring a fair, balanced, and engaging gaming environment requires addressing the asymmetry between players with different abilities.

Players are not defined by their disabilities, and misconstruing disability with game skill or knowledge might lead to players with disabilities and their opponents being evenly matched when their skills are not. This may not be a problem if the goal is to maximize enjoyment and challenge [6], but in competitive games where skill is expected to be rewarded (e.g., leaderboards and ranking systems), this raises additional challenges. In traditional sports, we isolate competitors based on their disabilities (e.g., Paralympics) and although they are considered fair, they do not provide the ability for mixed-ability engagement. We believe that in gaming, we can do more to create fair, competitive experiences without isolating players by leveraging asymmetry. However, not conflating skill with disability remains an open challenge.

In competitive mixed-ability play, incorporating asymmetry allows both players to feel **included**, **challenged**, and **engaged**, providing **equity** in the gaming experience.

5.3 Tensions between transparency and competitiveness

Online worlds can be a great place for disabilities to be invisible (by choice) [50, 33]. Equally important is representation [50, 33] without being a target of stereotypes that affect the experience or people's behaviors.

In mixed-ability asymmetric gaming, disability disclosure (i.e. making disabilities in/visible) can have consequences on the types of interaction between players that we can design. For example, how can we design games with matchmaking mechanisms for mixed-ability competitive games? Should we strive for transparency at all costs, or should we empower people with impairments to make the choice of disclosure? While disclosure is attributed to the user in cooperative and online worlds, should this remain a choice in competitive games where they are potentially competing in asymmetric challenges? Or should it be at least be perceivable in the ways in which each player is competing? There are tensions yet to be untangled between transparency and disclosure in mixed-ability competitive games that warrant further exploration.

6 Limitations

Despite the significant effort and time invested in developing the prototype, the gameplay experience may still differ from what participants are accustomed to in commercial games. The amount of training time participants had was short given the game's complexity, even though we attempted to mitigate this by sending the minigames in advance. The symmetric audio-only condition had a display of how many of the pairs of cards were completed for debugging and tracking purposes, and while it does not provide any feedback relevant to which or where the pair of cards were it can have influenced sighted participants' perceptions about the audio game. We also recognize that the design of each minigame cannot be disentangled from the results discussed. Additionally, sighted participants were, on average, 24 years old, compared to 37 for blind players, and played games more regularly, which may mean the differences in performance are due to skill and not an imbalance in the designed mechanics. The study's small sample size and diverse pool of participants should be considered when interpreting the results, as they are not meant to be generalizable, but a first exploration into the perceptions of mixed-ability competitive gaming. Our work contributes with insights into how players perceive fairness in symmetric/asymmetric competitive mixed-ability gaming, as well as the tensions of disability disclosure. We believe these findings pave the way for future research and development in inclusive play.

7 Conclusion

Gaming is an important part of many people's social lives, and we should strive to ensure gaming is an inclusive space for all. Competitive gaming poses additional challenges for mixed-ability gaming, particularly when past work's most promising approach for inclusive play relied on creating asymmetric experiences, and typically, competition expects symmetric play.

Our work is a first attempt at exploring competitive games for mixed-visual-ability groups. We focused on exploring the perceptions of fairness and engagement concerning asymmetric design choices. We conducted a mixed-method study with blind and sighted participants who played a competitive game and were exposed to four types of a/symmetries. Our findings have pointed to how symmetric challenge does not necessarily align with players' expectations of fairness and engagement, given the need to create asymmetric interfaces or restrict sighted players' access to a single modality. In line with past work on cooperative mixed-ability gaming but at odds with traditional notions of fairness, the most promising approach for competitive scenarios is to assume a high degree of asymmetry and have players compete in asymmetric challenges created based on their abilities. We highlight how asymmetric design is promising for supporting competitive mixed-ability but will require more careful design to guarantee that different in-game challenges are either equally demanding or that across the whole game experience, there is a balance of what we overall demand of players. We hope this work prompts new research in innovative game design approaches that embrace asymmetry to create more engaging and inclusive competitive experiences.

Acknowledgments. We thank the anonymous reviewers for their valuable feedback. This work was supported by FCT through project "Plug n' Play: Exploring Asymmetry and Modularity for Inclusive Game Design" ref. 2022.08895.PTDC (http://doi.org/10.54499/2022.08895.PTDC), scholarships ref. 2024.02901.BD, ref. UI/BD/151178/2021 (https://doi.org/10.54499/UI/BD/151178/2021) and ref. 2022.12448.BD, the Institutional CEEC, CEECINST/00032/2018/CP1523/CT0003 (https://doi.org/10.54499/CEECINST/00032/2018/CP1523/CT0003), and the LASIGE Research Unit, ref. UIDB/00408/2020 (https://doi.org/10.54499/UIDB/00408/2020)).

Disclosure of Interests. The authors have no competing interests to declare that are relevant to the content of this article.

References

1. Abeele, V.V., Spiel, K., Nacke, L., Johnson, D., Gerling, K.: Development and validation of the player experience inventory: A scale to measure player experiences at the level of functional and psychosocial consequences. International Journal of Human-Computer Studies **135**, 102370 (2020)
2. Andrade, R., Rogerson, M.J., Waycott, J., Baker, S., Vetere, F.: Playing blind: Revealing the world of gamers with visual impairment. In: Proceedings of the 2019 CHI Conference on Human Factors in Computing Systems. pp. 1–14 (2019)

3. Araújo, M.C.C., Façanha, A.R., Darin, T.G.R., Sánchez, J., Andrade, R.M.C., Viana, W.: Mobile Audio Games Accessibility Evaluation for Users Who Are Blind. In: Antona, M., Stephanidis, C. (eds.) Universal Access in Human–Computer Interaction. Designing Novel Interactions. pp. 242–259. Lecture Notes in Computer Science, Springer International Publishing, Cham (2017). https://doi.org/10.1007/978-3-319-58703-5_18
4. Archambault, D., Ossmann, R., Gaudy, T., Miesenberger, K.: Computer games and visually impaired people. Upgrade **8**(2), 43–53 (2007)
5. Atkinson, M.T., Gucukoglu, S., Machin, C.H.C., Lawrence, A.E.: Making the mainstream accessible: redefining the game. In: Proceedings of the 2006 ACM SIGGRAPH symposium on Videogames. pp. 21–28. Sandbox '06, Association for Computing Machinery, New York, NY, USA (Jul 2006). https://doi.org/10.1145/1183316.1183321, https://doi.org/10.1145/1183316.1183321
6. Baldwin, A., Johnson, D., Wyeth, P., Sweetser, P.: A framework of dynamic difficulty adjustment in competitive multiplayer video games. In: 2013 IEEE international games innovation conference (IGIC). pp. 16–19. IEEE (2013)
7. Bierre, K., Chetwynd, J., Ellis, B., Hinn, D.M., Ludi, S., Westin, T.: Game not over: Accessibility issues in video games. In: Proc. of the 3rd International Conference on Universal Access in Human-Computer Interaction. pp. 22–27 (2005)
8. Braun, V., Clarke, V.: One size fits all? what counts as quality practice in (reflexive) thematic analysis? Qualitative Research in Psychology **18**(3), 328–352 (2021). https://doi.org/10.1080/14780887.2020.1769238, https://doi.org/10.1080/14780887.2020.1769238
9. Cheung, G., Huang, J.: Starcraft from the stands: understanding the game spectator. In: Proceedings of the SIGCHI conference on human factors in computing systems. pp. 763–772 (2011)
10. Csapó, A., Wersényi, G., Nagy, H., Stockman, T.: A survey of assistive technologies and applications for blind users on mobile platforms: a review and foundation for research. Journal on Multimodal User Interfaces **9**(4), 275–286 (Dec 2015). https://doi.org/10.1007/s12193-015-0182-7
11. Depping, A.E., Mandryk, R.L., Li, C., Gutwin, C., Vicencio-Moreira, R.: How disclosing skill assistance affects play experience in a multiplayer first-person shooter game. In: Proceedings of the 2016 CHI Conference on Human Factors in Computing Systems. p. 3462–3472. CHI '16, Association for Computing Machinery, New York, NY, USA (2016). https://doi.org/10.1145/2858036.2858156, https://doi.org/10.1145/2858036.2858156
12. Dog, N.: *The Last of Us Part II*. Digital game [Playstation] (6 2020), https://www.playstation.com/en-us/games/the-last-of-us-part-ii/accessibility/
13. Friberg, J., Gärdenfors, D.: Audio games: new perspectives on game audio. In: Proceedings of the 2004 ACM SIGCHI International Conference on Advances in computer entertainment technology. pp. 148–154. ACE '04, Association for Computing Machinery, New York, NY, USA (Sep 2004). https://doi.org/10.1145/1067343.1067361, https://doi.org/10.1145/1067343.1067361
14. Fullerton, T.: Game design workshop: a playcentric approach to creating innovative games. CRC press (2014). https://doi.org/10.1201/b22309
15. Gerling, K., Buttrick, L.: Last tank rolling: exploring shared motion-based play to empower persons using wheelchairs. In: Proceedings of the first ACM SIGCHI annual symposium on Computer-human interaction in play. pp. 415–416. CHI PLAY '14, Association for Computing Machinery, New York, NY,

USA (Oct 2014). https://doi.org/10.1145/2658537.2661303, https://doi.org/10.1145/2658537.2661303
16. Ghost Town Games Ltd., T.: *Overcooked! 2*. Digital game [Nintendo Switch] (8 2018), https://www.team17.com/games/overcooked-2/
17. Gonçalves, D., Piçarra, M., Pais, P., Guerreiro, J., Rodrigues, A.: " my zelda cane": Strategies used by blind players to play visual-centric digital games. In: Proceedings of the 2023 CHI conference on human factors in computing systems. pp. 1–15 (2023)
18. Gonçalves, D., Pais, P., Gerling, K., Guerreiro, T., Rodrigues, A.: Social gaming: A systematic review. Computers in Human Behavior **147**, 107851 (2023). https://doi.org/10.1016/j.chb.2023.107851, https://www.sciencedirect.com/science/article/pii/S0747563223002029
19. Gonçalves, D., Rodrigues, A., Guerreiro, T.: Playing With Others: Depicting Multiplayer Gaming Experiences of People With Visual Impairments. In: The 22nd International ACM SIGACCESS Conference on Computers and Accessibility. pp. 1–12. ASSETS '20, Association for Computing Machinery, New York, NY, USA (Oct 2020). https://doi.org/10.1145/3373625.3418304, https://doi.org/10.1145/3373625.3418304
20. Gonçalves, D., Rodrigues, A., Richardson, M.L., de Sousa, A.A., Proulx, M.J., Guerreiro, T.: Exploring Asymmetric Roles in Mixed-Ability Gaming. In: Proceedings of the 2021 CHI Conference on Human Factors in Computing Systems, pp. 1–14. No. 114, Association for Computing Machinery, New York, NY, USA (May 2021), https://doi.org/10.1145/3411764.3445494
21. Grabski, A., Toni, T., Zigrand, T., Weller, R., Zachmann, G.: Kinaptic - techniques and insights for creating competitive accessible 3d games for sighted and visually impaired users. In: 2016 IEEE Haptics Symposium (HAPTICS). p. 325–331 (Apr 2016). https://doi.org/10.1109/HAPTICS.2016.7463198
22. Grammenos, D., Savidis, A., Stephanidis, C.: Ua-chess: A universally accessible board game p. 11
23. Grammenos, D.: Game over: learning by dying. In: Proceedings of the SIGCHI Conference on Human Factors in Computing Systems. pp. 1443–1452. CHI '08, Association for Computing Machinery, New York, NY, USA (Apr 2008). https://doi.org/10.1145/1357054.1357281, https://doi.org/10.1145/1357054.1357281
24. Grammenos, D., Savidis, A., Georgalis, Y., Stephanidis, C.: Access Invaders: Developing a Universally Accessible Action Game. In: Miesenberger, K., Klaus, J., Zagler, W.L., Karshmer, A.I. (eds.) Computers Helping People with Special Needs. pp. 388–395. Lecture Notes in Computer Science, Springer, Berlin, Heidelberg (2006). https://doi.org/10.1007/11788713_58
25. Grammenos, D., Savidis, A., Stephanidis, C.: Designing universally accessible games. Computers in Entertainment **7**(1), 8:1–8:29 (Feb 2009). https://doi.org/10.1145/1486508.1486516, https://doi.org/10.1145/1486508.1486516
26. Gugenheimer, J., Stemasov, E., Frommel, J., Rukzio, E.: Sharevr: Enabling co-located experiences for virtual reality between hmd and non-hmd users. In: Proceedings of the 2017 CHI Conference on Human Factors in Computing Systems. pp. 4021–4033 (2017)
27. Gugenheimer, J., Stemasov, E., Sareen, H., Rukzio, E.: Facedisplay: Towards asymmetric multi-user interaction for nomadic virtual reality. In: Proceedings of the 2018 CHI Conference on Human Factors in Computing Systems. pp. 1–13 (2018)

28. Hamari, J., Sjöblom, M.: What is esports and why do people watch it? Internet research (2017)
29. Harris, J., Hancock, M., Scott, S.D.: Leveraging Asymmetries in Multiplayer Games: Investigating Design Elements of Interdependent Play. In: Proceedings of the 2016 Annual Symposium on Computer-Human Interaction in Play. pp. 350–361. CHI PLAY '16, Association for Computing Machinery, New York, NY, USA (Oct 2016). https://doi.org/10.1145/2967934.2968113, `https://doi.org/10.1145/2967934.2968113`
30. IllFonic: *Predator: Hunting Grounds*. Digital game [Microsoft Windows] (4 2020), `https://predator.illfonic.com/`
31. Infinity Ward, S.: *Call of Duty: Modern Warfare 3*. Digital game [Microsoft Windows] (11 2023), `https://www.callofduty.com/en/modernwarfare3`
32. Kirke, A.: When the soundtrack is the game: From audio-games to gaming the music. Emotion in Video Game Soundtracking pp. 65–83 (2018)
33. Mack, K., Hsu, R.C.L., Monroy-Hernández, A., Smith, B.A., Liu, F.: Towards inclusive avatars: Disability representation in avatar platforms. In: Proceedings of the 2023 CHI Conference on Human Factors in Computing Systems. CHI '23, Association for Computing Machinery, New York, NY, USA (2023). https://doi.org/10.1145/3544548.3581481, `https://doi.org/10.1145/3544548.3581481`
34. Miesenberger, K., Ossmann, R., Archambault, D., Searle, G., Holzinger, A.: More than just a game: Accessibility in computer games. In: Holzinger, A. (ed.) HCI and Usability for Education and Work. p. 247–260. Lecture Notes in Computer Science, Springer (2008). https://doi.org/10.1007/978-3-540-89350-9_18
35. Musick, G., Freeman, G., McNeese, N.J.: Gaming as family time: Digital game co-play in modern parent-child relationships. Proceedings of the ACM on Human-Computer Interaction **5**(CHI PLAY), 1–25 (2021)
36. Nair, V., Karp, J.L., Silverman, S., Kalra, M., Lehv, H., Jamil, F., Smith, B.A.: NavStick: Making Video Games Blind-Accessible via the Ability to Look Around. In: The 34th Annual ACM Symposium on User Interface Software and Technology. pp. 538–551. ACM, Virtual Event USA (Oct 2021). https://doi.org/10.1145/3472749.3474768, `https://dl.acm.org/doi/10.1145/3472749.3474768`
37. Nair, V., Ma, S.e., Gonzalez Penuela, R.E., He, Y., Lin, K., Hayes, M., Huddleston, H., Donnelly, M., Smith, B.A.: Uncovering visually impaired gamers' preferences for spatial awareness tools within video games. In: Proceedings of the 24th International ACM SIGACCESS Conference on Computers and Accessibility. ASSETS '22, Association for Computing Machinery, New York, NY, USA (2022). https://doi.org/10.1145/3517428.3544802, `https://doi.org/10.1145/3517428.3544802`
38. Ossmann, R., Miesenberger, K., Archambault, D.: A computer game designed for all. In: Miesenberger, K., Klaus, J., Zagler, W., Karshmer, A. (eds.) Computers Helping People with Special Needs. p. 585–592. Lecture Notes in Computer Science, Springer (2008). https://doi.org/10.1007/978-3-540-70540-6_83
39. Piçarra, M., Rodrigues, A., Guerreiro, J.a.: Evaluating accessible navigation for blind people in virtual environments. In: Extended Abstracts of the 2023 CHI Conference on Human Factors in Computing Systems. CHI EA '23, Association for Computing Machinery, New York, NY, USA (2023). https://doi.org/10.1145/3544549.3585813, `https://doi.org/10.1145/3544549.3585813`

40. Porter, J.R., Kientz, J.A.: An empirical study of issues and barriers to mainstream video game accessibility. In: Proceedings of the 15th International ACM SIGACCESS Conference on Computers and Accessibility. ASSETS '13, Association for Computing Machinery, New York, NY, USA (2013). https://doi.org/10.1145/2513383.2513444, https://doi.org/10.1145/2513383.2513444
41. Pragma: *Crazy Party*. Digital game [Microsoft Windows] (5 2016), http://pragmapragma.free.fr/crazy-party/en/index.php
42. Smith, B.A., Nayar, S.K.: The RAD: Making Racing Games Equivalently Accessible to People Who Are Blind. In: Proceedings of the 2018 CHI Conference on Human Factors in Computing Systems, pp. 1–12. Association for Computing Machinery, New York, NY, USA (Apr 2018), https://doi.org/10.1145/3173574.3174090
43. Sobel, K., Bhattacharya, A., Hiniker, A., Lee, J.H., Kientz, J.A., Yip, J.C.: It wasn't really about the pokémon: parents' perspectives on a location-based mobile game. In: Proceedings of the 2017 CHI Conference on Human Factors in Computing Systems. pp. 1483–1496 (2017)
44. Studio, S.M.: *God of War Ragnarök*. Digital game [Playstation] (11 2022), https://www.playstation.com/en-us/games/god-of-war-ragnarok/accessibility/
45. Turn 10 Studios, Playground Games, S.: *Forza Motorsport*. Digital game [Xbox] (10 2023), https://www.xbox.com/en-us/games/forza-motorsport
46. VGStorm: *Manamon*. Digital game [Microsoft Windows] (7 2016), http://www.vgstorm.com/manamon.php
47. Wen, J., Kow, Y.M., Chen, Y.: Online games and family ties: Influences of social networking game on family relationship. In: Human-Computer Interaction–INTERACT 2011: 13th IFIP TC 13 International Conference, Lisbon, Portugal, September 5-9, 2011, Proceedings, Part III 13. pp. 250–264. Springer (2011)
48. Yuan, B., Folmer, E.: Blind hero: Enabling guitar hero for the visually impaired. In: Proceedings of the 10th International ACM SIGACCESS Conference on Computers and Accessibility. p. 169–176. Assets '08, Association for Computing Machinery, New York, NY, USA (2008). https://doi.org/10.1145/1414471.1414503, https://doi.org/10.1145/1414471.1414503
49. Yuan, B., Folmer, E., Harris, F.C.: Game accessibility: a survey. Universal Access in the Information Society **10**(1), 81–100 (Mar 2011). https://doi.org/10.1007/s10209-010-0189-5, https://doi.org/10.1007/s10209-010-0189-5
50. Zhang, K., Deldari, E., Lu, Z., Yao, Y., Zhao, Y.: "it's just part of me:" understanding avatar diversity and self-presentation of people with disabilities in social virtual reality. In: Proceedings of the 24th International ACM SIGACCESS Conference on Computers and Accessibility. ASSETS '22, Association for Computing Machinery, New York, NY, USA (2022). https://doi.org/10.1145/3517428.3544829, https://doi.org/10.1145/3517428.3544829